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Target and Shaped Charge Alignment

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Target and Shaped Charge Alignment

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Abstract

The procedures used by the U.S. Army Research Laboratory, Weapons Technology Directorate, Armor Mechanics Branch, to position and align a shaped charge, chemical energy (CE) warhead are discussed in detail. Special coverage of methods for range crew warhead placement and alignment to impact certain target positions at specific azimuth, elevation, and obliquity is detailed in this report.

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1. BACKGROUND

Part of the development of an armor system, effective against a robust chemical energy (CE) warhead, requires testing an armor at various attack azimuths and hit locations, in a manner that ensures an accurate, cost-effective, and meaningful test. Certain weak points in the armor might need investigation and improvement. Therefore, in the alignment of an armor system and a CE warhead, a certain standard of setup must be established that enables the control of the exact point of armor disturbance. This is accomplished through careful and consistent placement of armor components relative to the CE warhead jet path.

This report documents the routine procedures used by the U.S. Army Research Laboratory, Weapons and Materials Research Directorate, Armor Mechanics Branch, during CE warhead testing. These procedures ensure that the warhead and target are positioned correctly so as to allow a statistically repeatable test that minimizes the shot-to-shot variation in test results.

2. STEP-BY-STEP PROCEDURES FOR TARGET/WARHEAD ALIGNMENT

2.1 Target Setup and Test Table Placement. To accommodate the CE warhead and/or target setup, a level, flat surface must be used. This level surface can be provided by using a test table—a 1-in piece of plywood—to cover an existing range surface. Note: The target height on the test table may need adjustment to allow charge placement a minimum of 6 in from any robust steel range surface. The plywood surface of the test table, both cases a and b below, should be leveled with a machinist's level in two directions 90° apart, parallel and perpendicular to the proposed shot line. (See Figure 1 for a description of test table usage and overall test schematic.)

For smaller targets (case a), the plywood sheet may be reinforced on both sides by 2-in × 4-in studs (required to support target mass). It should be large enough to accommodate the target and CE warhead at the appropriate standoff.

If the target is too heavy to sit on a plywood surface (case b), then the target itself should be properly positioned with adjustment wedges, and a test table will be positioned and secured in front of the target for the warhead placement (a piece of 1-in plywood, leveled, and supported with 2-in × 4-in studs as required). Again, see Figure 1 for test table usage.

In both of the previous cases, the test engineer shall specify the appropriate gunner's quadrant checks or inclinometer readings (at specific points on the target) to ensure proper target positioning. (Refer to Figure 2 for typical gunner's quadrant or reference mark locations.) The reference marks or alignment locations on target will be located and checked with the gunner's quadrant or inclinometer for proper setting. These reference points should have been discussed at the briefing with the test engineer. A target should not be placed upon a range table without some checks for proper positioning.

2.2 Horizontal Level Line and Vertical Plumb Line Placement. The impact point on target will be located per the test engineer's instructions. A horizontal level line and a vertical plumb line (cross hair) will be sketched after checking for level and plumb. (See Figure 3 for a schematic of cross-hair placement.) These cross-hair lines should be used for all subsequent setups of CE warheads. (Note: The proper placement of these lines is crucial.)

2.3 Transposing Target Center-Line (Shot Line) to Test Table Surface.* The shot line will be transposed onto the test table plywood surface using a framing square lined up with a level line and a plumb line. (See Figure 3 for a schematic of the placement of reference lines on the table.) A framing square and plastic triangles are used in this process. The framing square is placed on the target's front surface along the horizontal level line with the 90° corner aligned with the cross-hair center. Then the triangle is placed in contact with the edge of the framing square (triangle 90° corner should be placed against plywood table surface) and the shot line is transposed onto the table. This process provides an accurate reference line on the shot table for future use in setting the CE warhead.

2.4 Standoff Distance Determination. After the test table has been prepared, the appropriate standoff is marked on the test table surface. This is accomplished by using a framing square, machinist's level, and plastic triangle. The framing square is aligned on the cross hairs, as in Figure 4, while using the machinist's level to level the square. The triangle is placed against the framing square at the standoff location, the standoff is marked on the reference line on the test table, and a perpendicular line is drawn indicating standoff position.

* This line can also be predetermined on smaller scale shots, allowing the centerline to be placed on the table before setting target. Align front and center marks on target with line drawn on table.

The standoff of a warhead should be established by the test engineer (usually during the test briefing) and must be made clear to the test director for determination of his reference points for standoff. A standoff distance from an arbitrary and accessible reference point located on the munitions must be provided.

2.5 Warhead Height Determination. The height for the placement of the warhead is determined using a carpenter's square, machinist's level, and engineer's scale. The bottom edge of the framing level is positioned on the horizontal level line with one end at the center of the cross hairs. After adjusting the framing level to center "bubble," the height of the bottom edge of the framing level is measured above the table with a millimeter scale. Excellent results are obtained from this exercise if it is carried out by two test crewmembers. One crewmember holds the level on the cross hairs and levels the framing level, while the other takes a height reading from the level to the test table surface. The height of the cross hairs is recorded for future use in positioning the CE warhead. See Figure 4b for the schematic of charge height measurement. (Note: Charge height should be a minimum of 6 in from any robust surface. This ensures that reflected blast waves do not interfere with proper functioning of the CE warhead.)

2.6 Warhead Positioning.

• Charge Stand Selection - Most charge stands are prepared before the test and are made out of various materials, depending on the size of the charge (see Figure 5). The preferred stand would be made out of plywood or foam (½ in thick), cut and measured for precision alignment. The height should be written on the side of the charge stand. The proper stand and charge combination are carefully selected after completing the warhead height measurement as per section 2.5. The operator should be totally familiar with his charge and stand combination and should be prepared to make small adjustments in height at the test site. In certain situations, a stand and charge combination may not have been predetermined, but time must be taken to ensure that the warhead is the exact height recorded by the test crew. At this time, the warhead is placed in the charge stand on the plywood test stand/shot table in approximately the correct position as indicated by the standoff mark penciled in section 2.4. The 90° triangle is placed on the standoff mark while sliding the shaped charge and stand against the 90° edge (see Figure 6).

• Level Adjustment - A machinist's level is used to check the level of the warhead axis. The level is placed on the long axis of the warhead and wedges are used to maintain level. Figure 7 is a schematic showing the leveling process.

• Initial Height Adjustment - The charge stand height adjustment must be done with spacers of the same dimensions as the stand (thickness will vary from 1/32 in, 1/16 in, 1/4 in, etc.). The height is checked before aligning by first leveling the warhead as described previously in "Charge Stand Selection." The height to the center of the detonator hole is then measured. Spacers are added as necessary. (Note: Do not attempt to raise the height of the charge with wedges alone.) See Figure 8 for height schematic adjustment.

• Azimuth Adjustment - When the charge height is approximately correct, alignment of the warhead can be continued by centering the front and back of the warhead on the shot line, which was marked on the test table in section 2.4. See Figures 9a and 9b for a description of this process.

To check that the detonator hole is centered over the shot line, a 90° triangle is used at the rear of the warhead. The 90° corner of the triangle is placed on the shot line and adjusted rear left and right until centered (see Figure 9a).

At the front of the warhead, the center of the cone should be over the shot line. A convenient method for accomplishing this is to mark the center of warhead liner at top and bottom with a marker. Then use a right triangle to center these marks over the shot line, checking back and front in a repetitious process until satisfied (see Figure 9b).

After the warhead has been leveled, the azimuth and height of the charge should be checked again. The procedure to set level, height, is a repetitious process where changes to one adjustment (level, height, or azimuth) may affect other alignments. If any changes are necessary, the corrections are made, and height and elevation are checked again. When no corrections are necessary, the process is complete and the warhead is aligned and ready to fire.

When satisfied with your adjustments, the charge stand should be secured by either gluing, taping, or using another method as appropriate. The alignment should be rechecked once more to ensure securing has not affected setup.

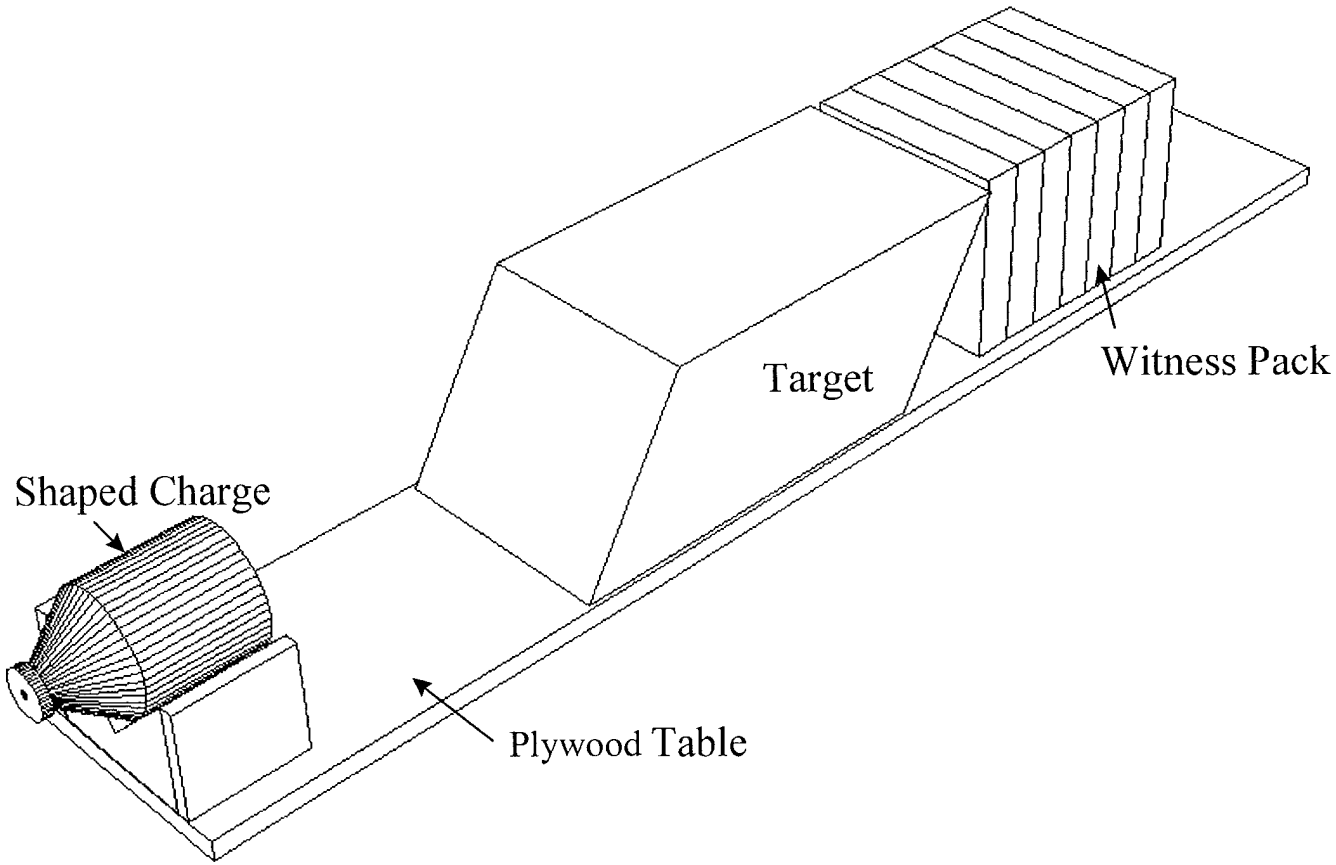
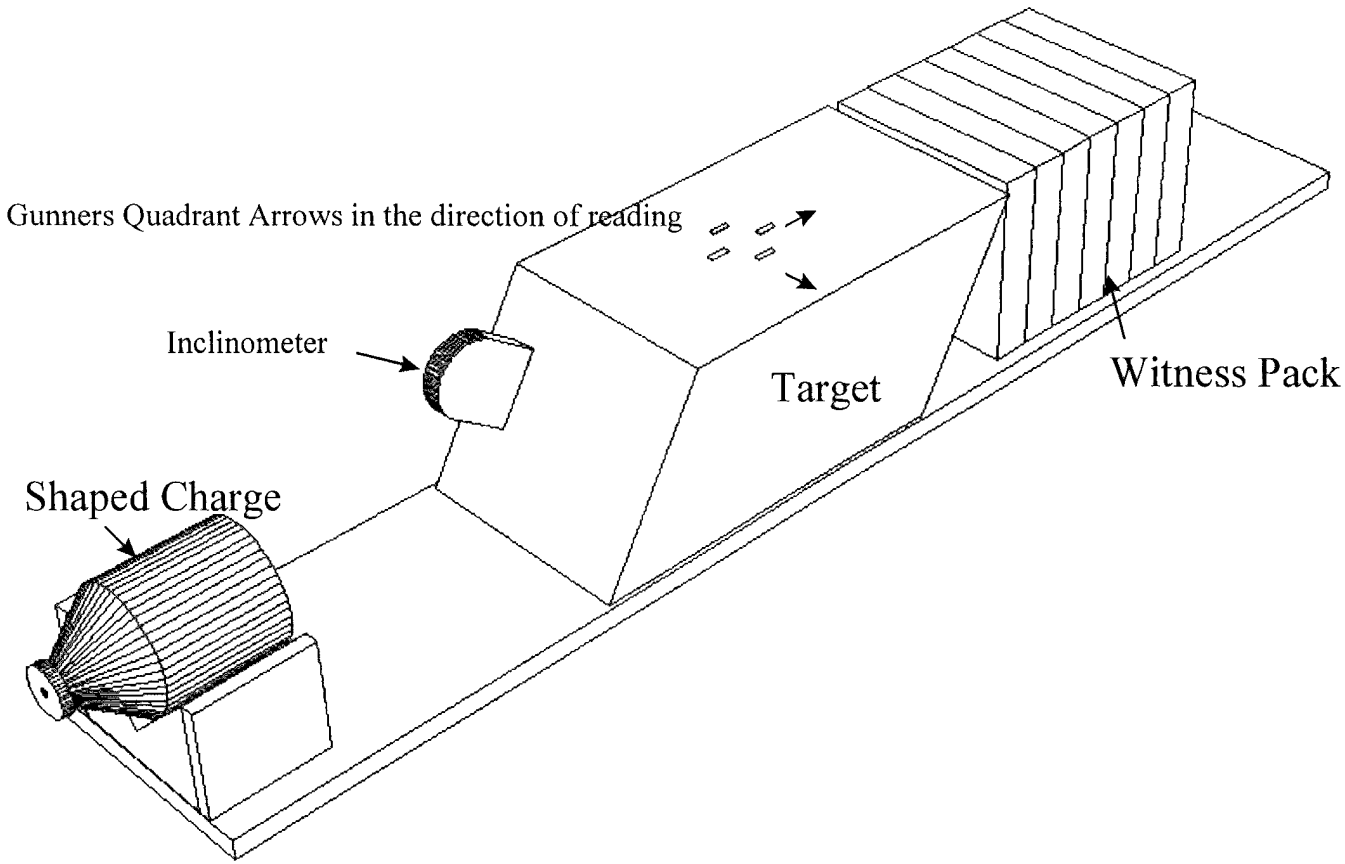


Figure 1. Overall schematic and test table usage



(a) Square indicators drawn on target by target assembly personnel will show placement of gunners quadrant. Note arrow direction of quadrant.

(b) Inclinometer: Area should be marked where inclinometer readings are desired.

Figure 2. Locating cross hairs/impact point on target

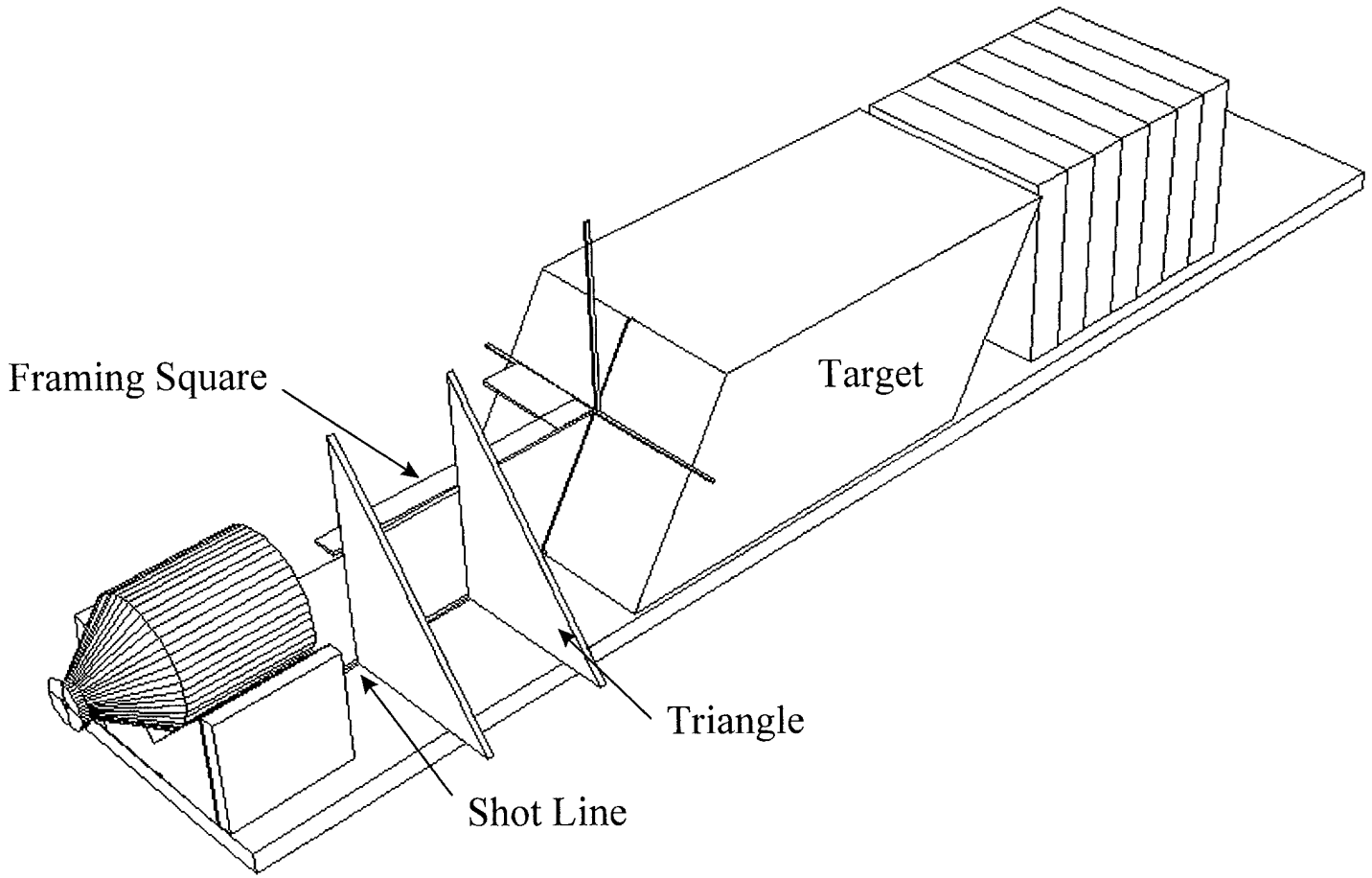


Figure 3. Transposing shot line onto test table.

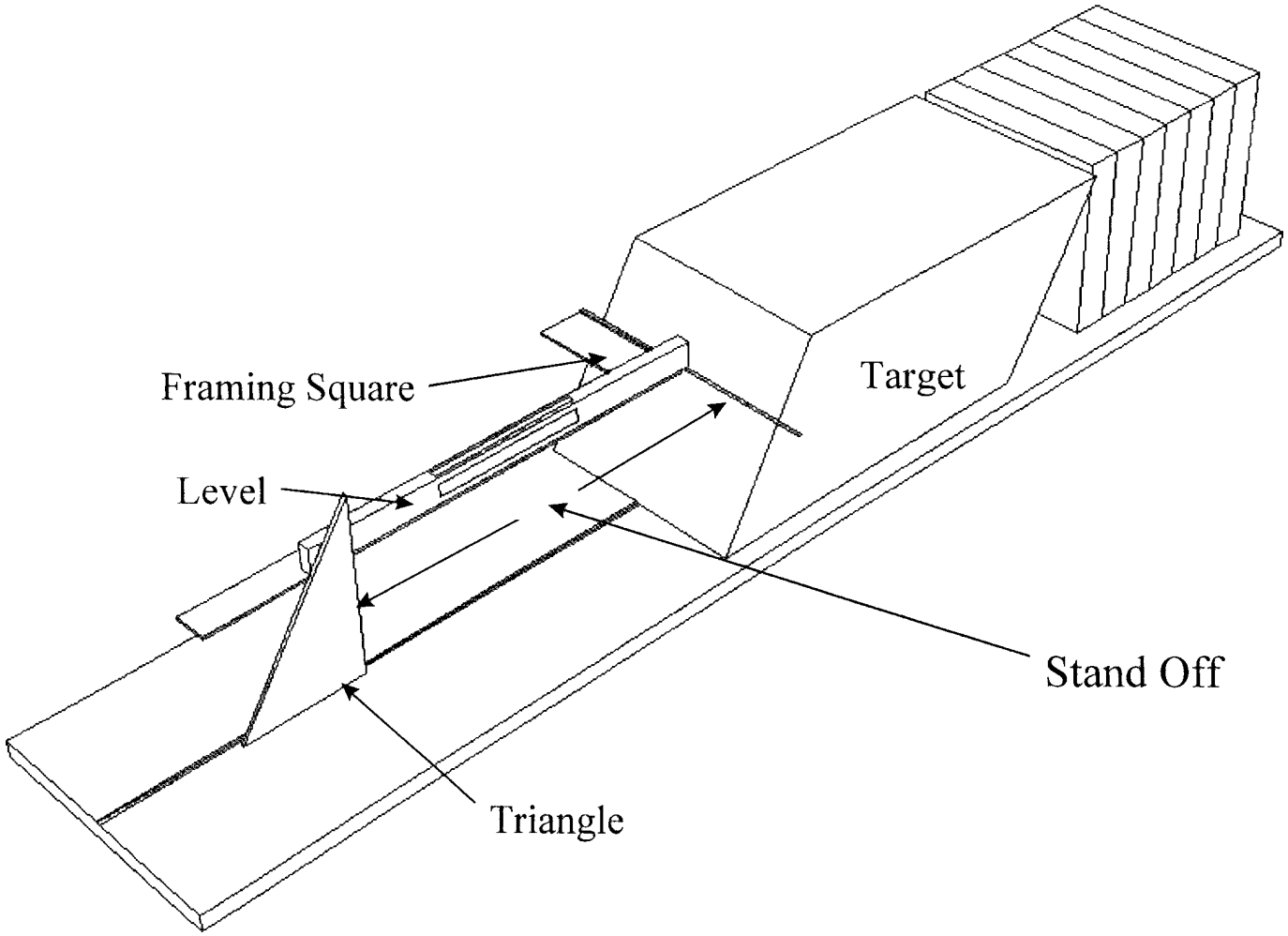


Figure 4a. Measuring standoff distance.

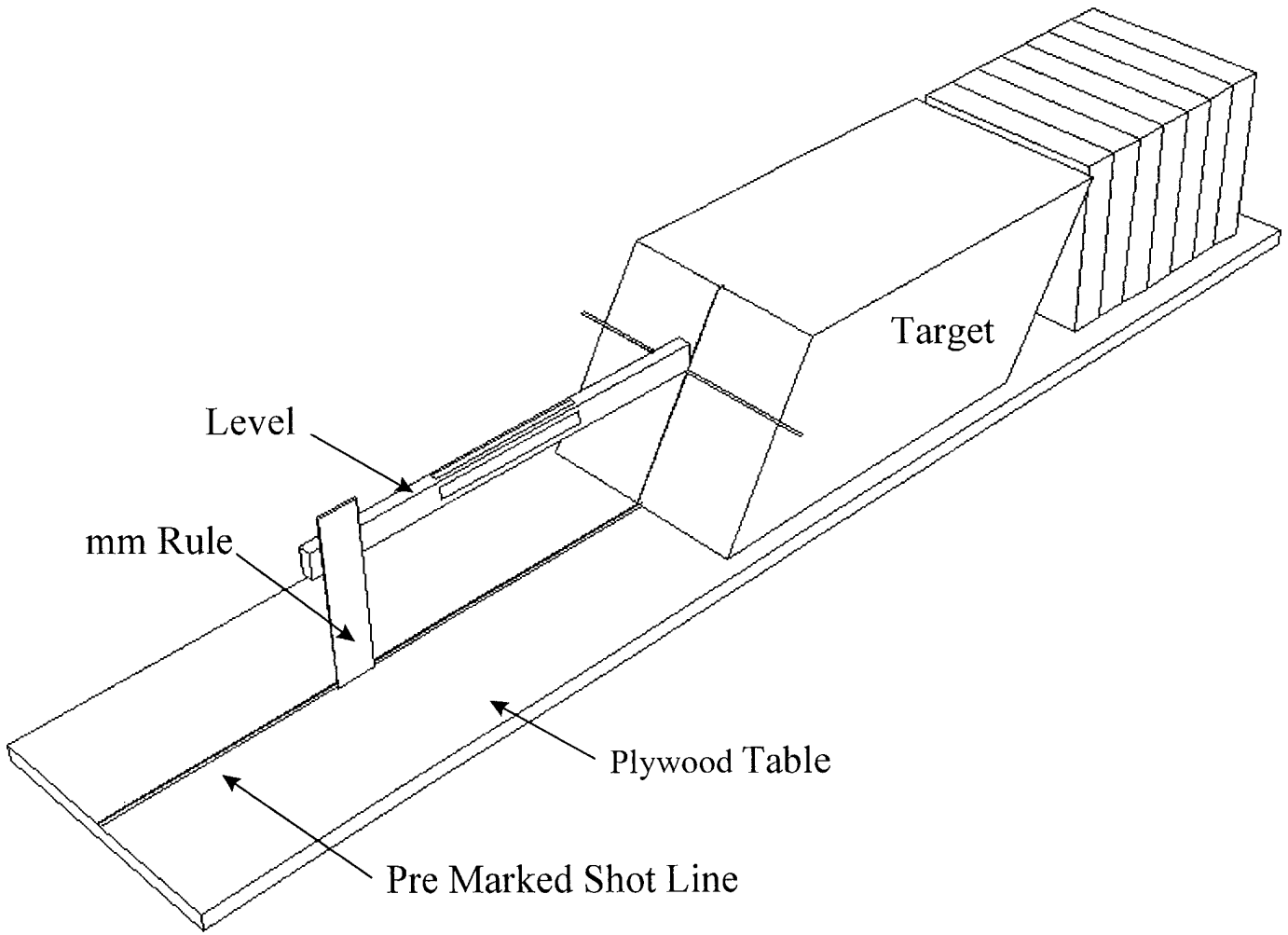


Figure 4b. Charge height initial measurement.

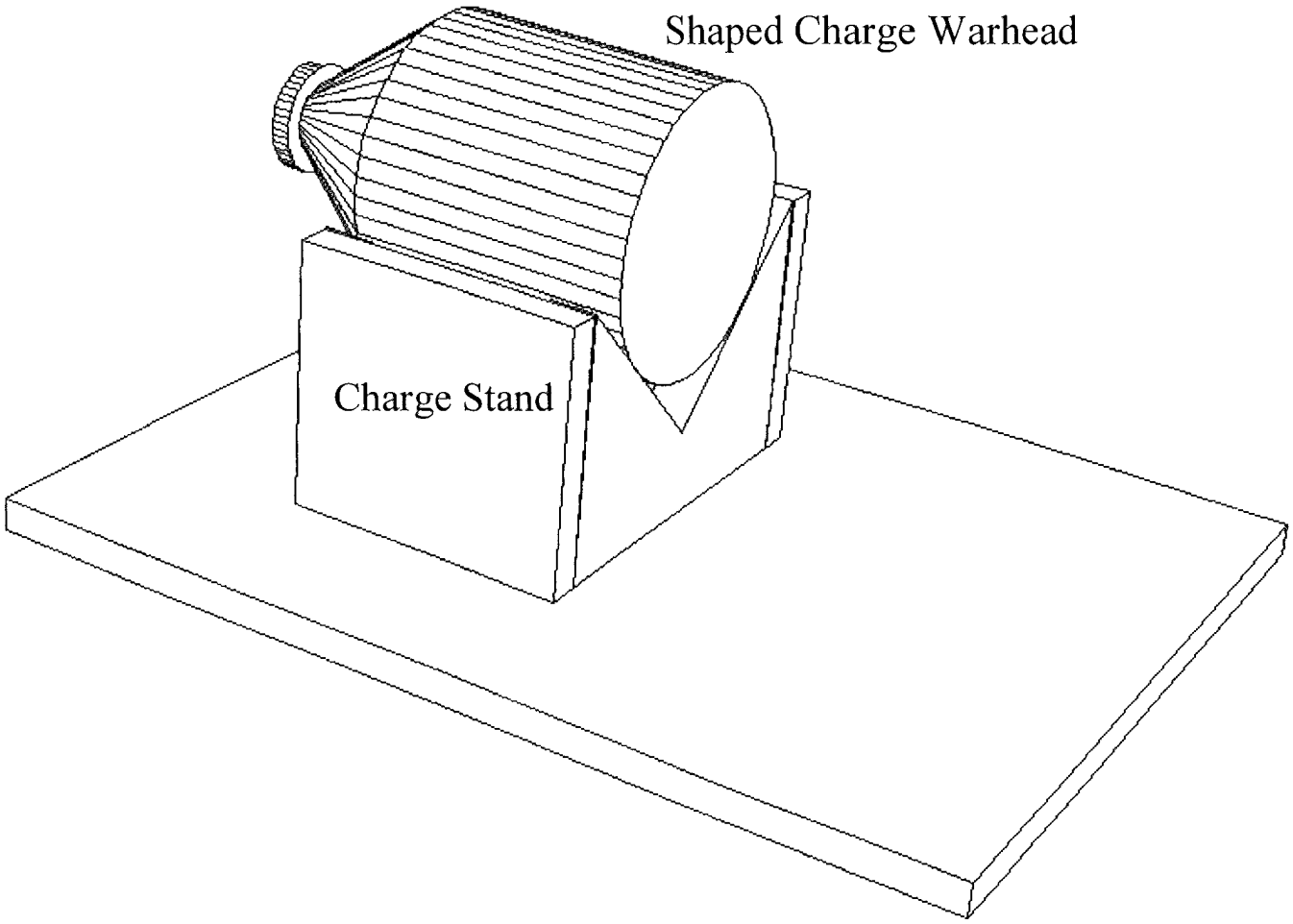


Figure 5. Charge stand schematic.

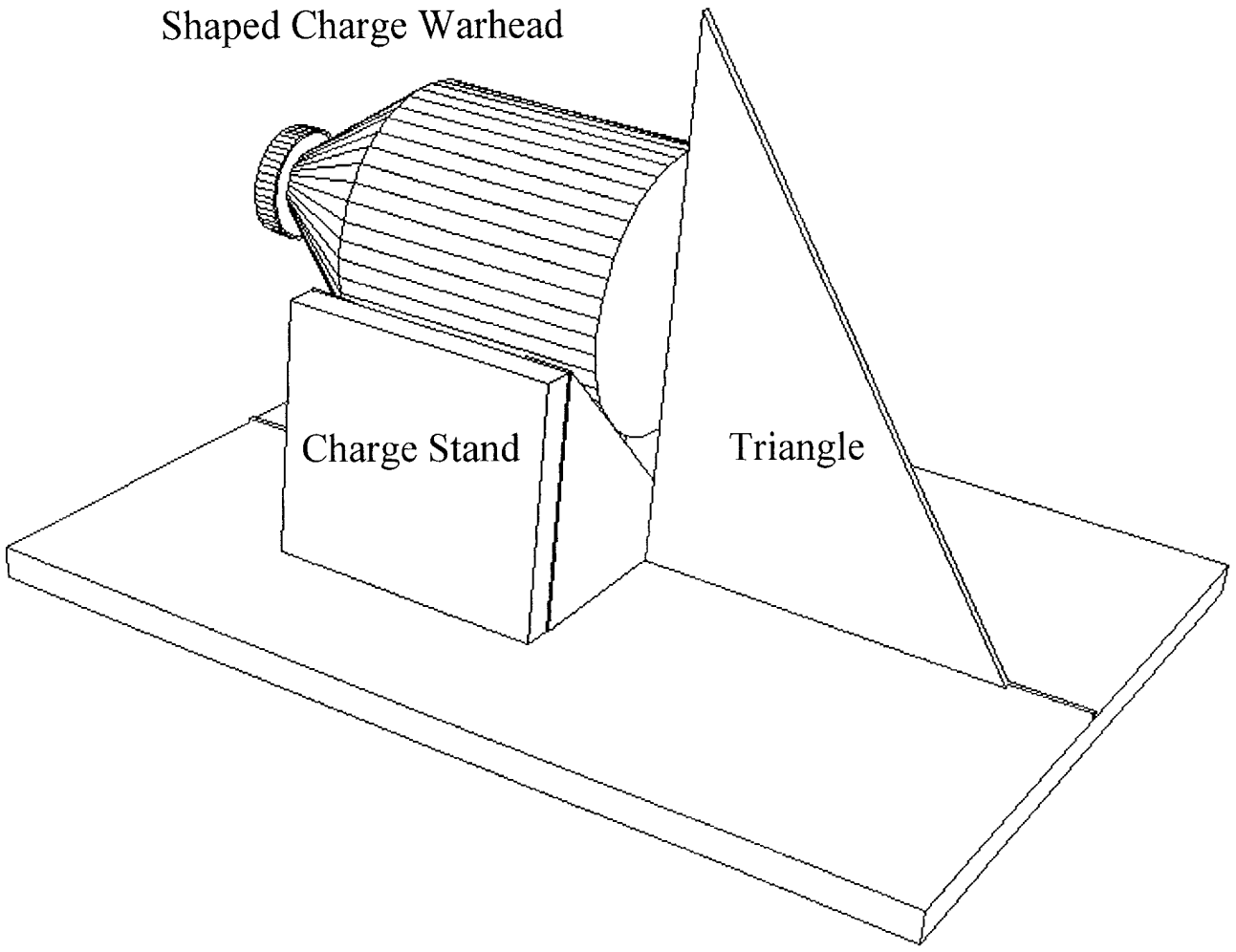


Figure 6. Placing warhead in premarked standoff position with plastic triangle.

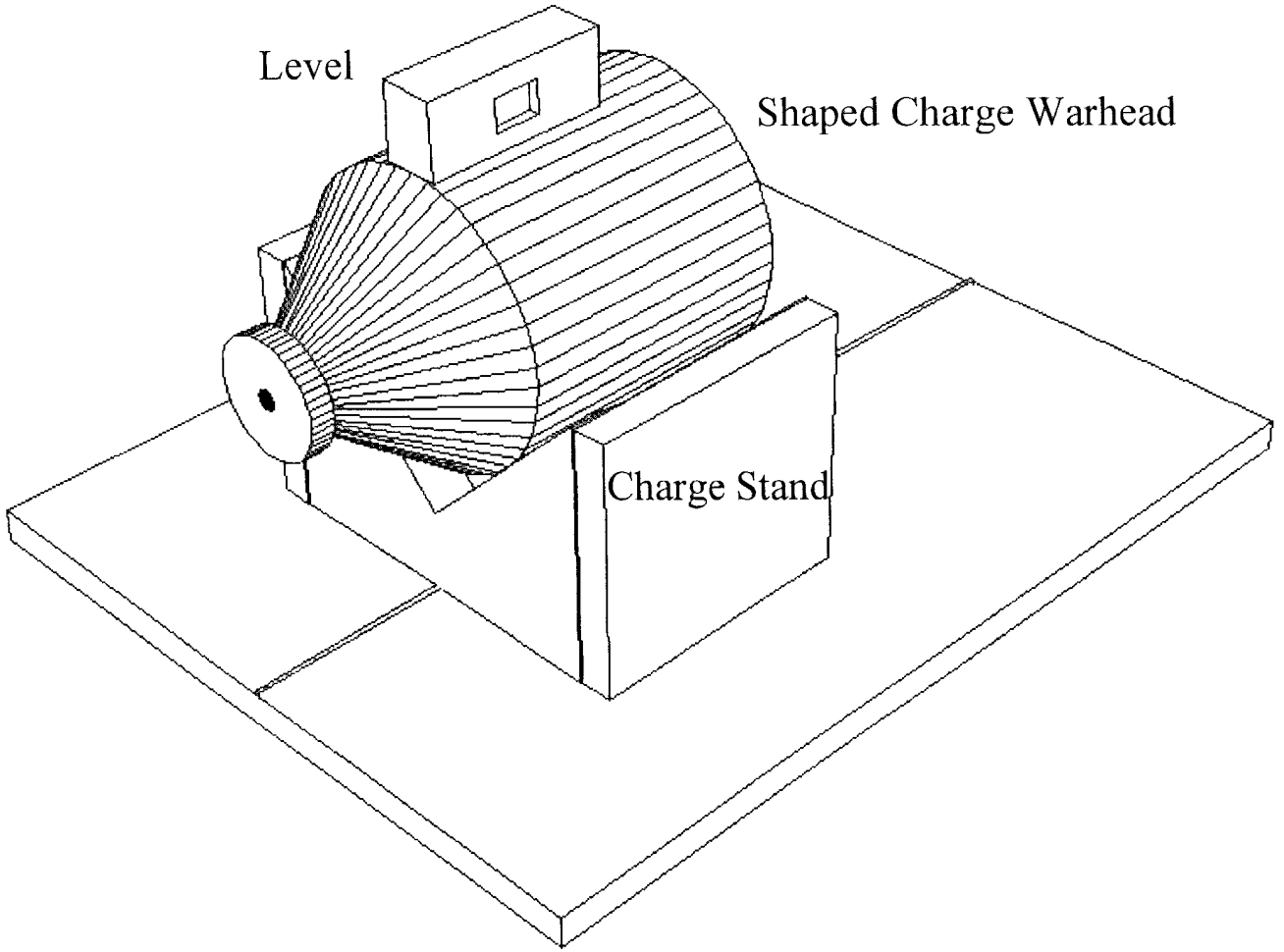


Figure 7. <u>Level adjustment.</u>

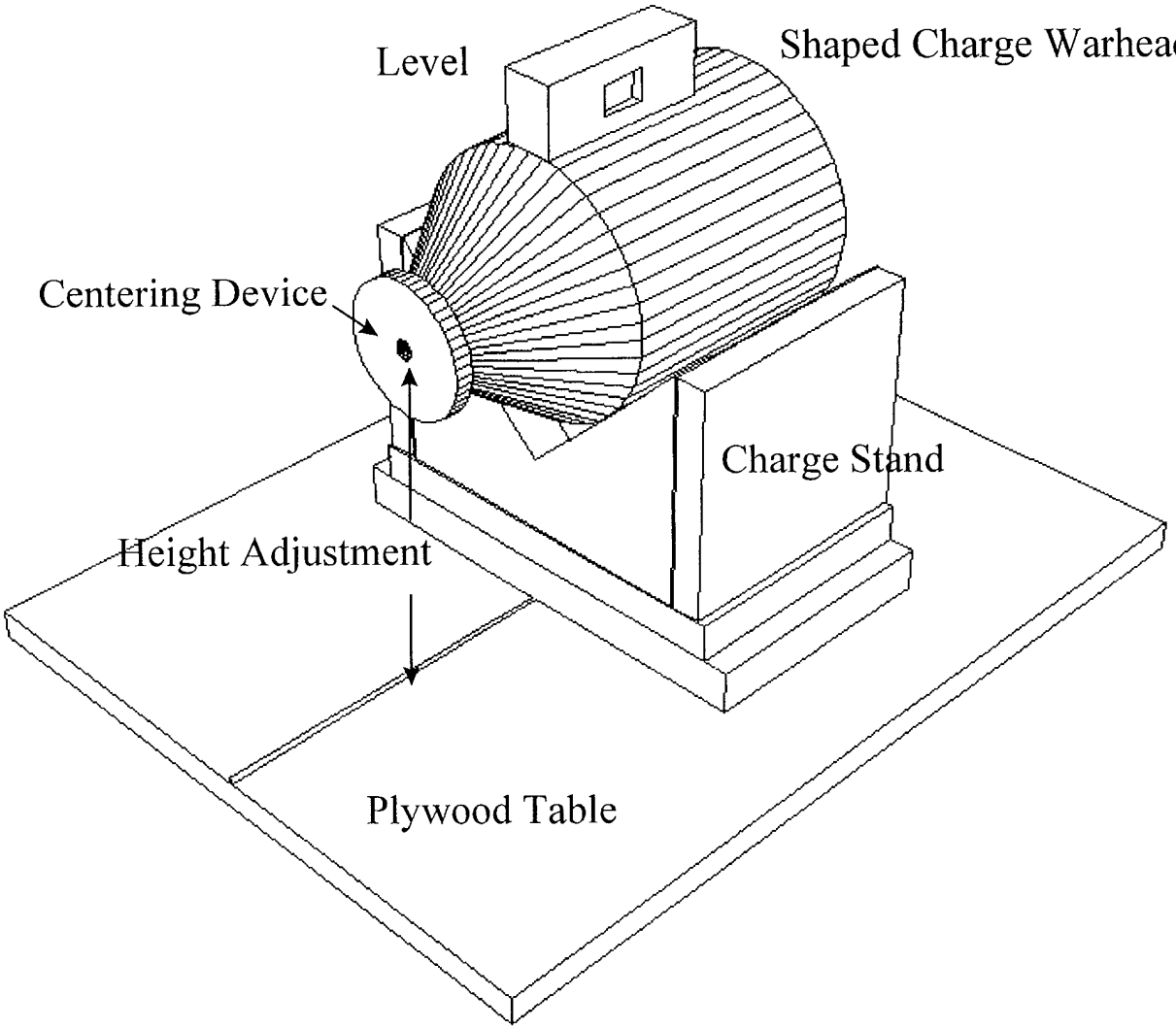


Figure 8. Height adjustment.

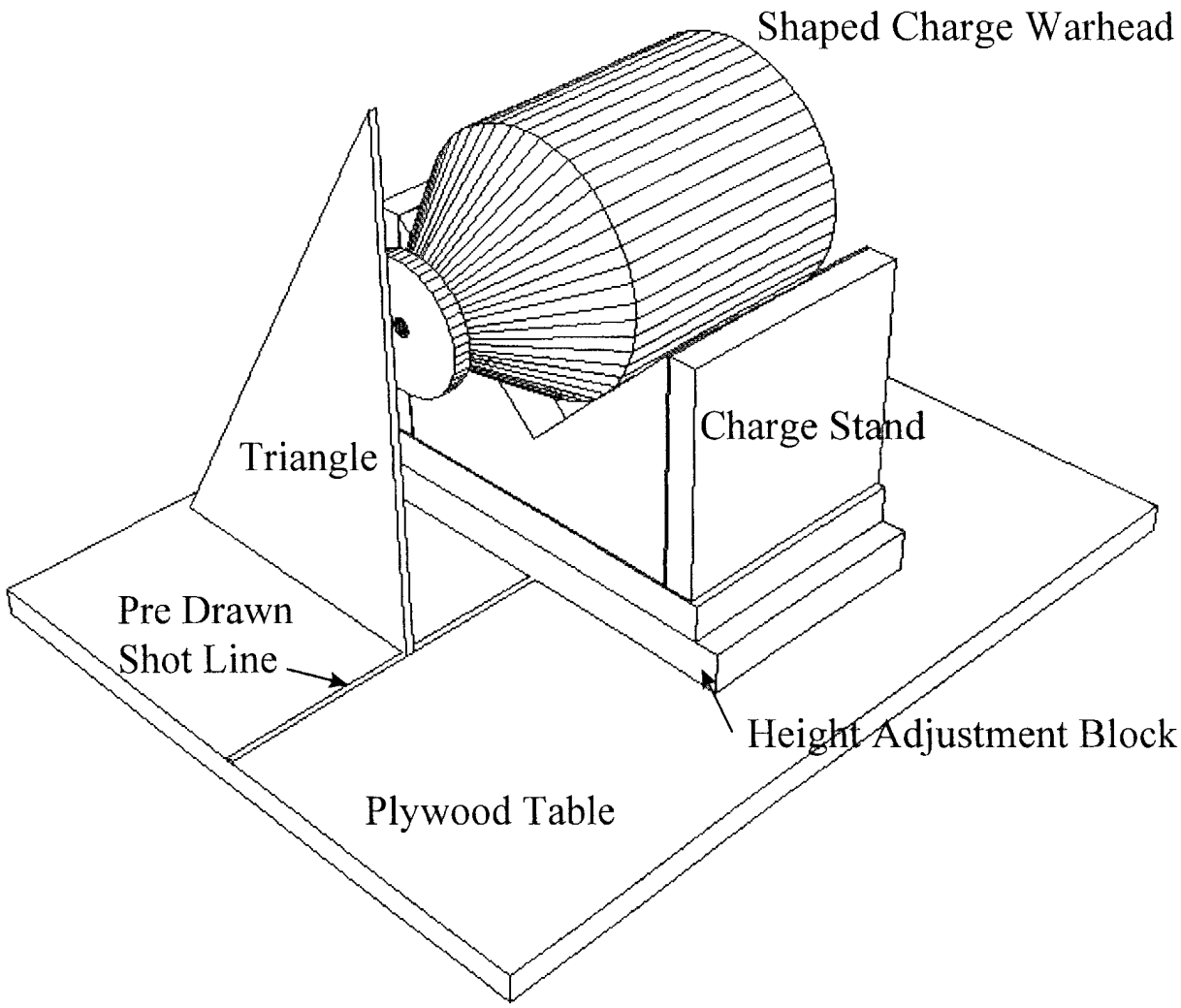


Figure 9a. <u>Rear of warhead centering with plastic triangle</u>

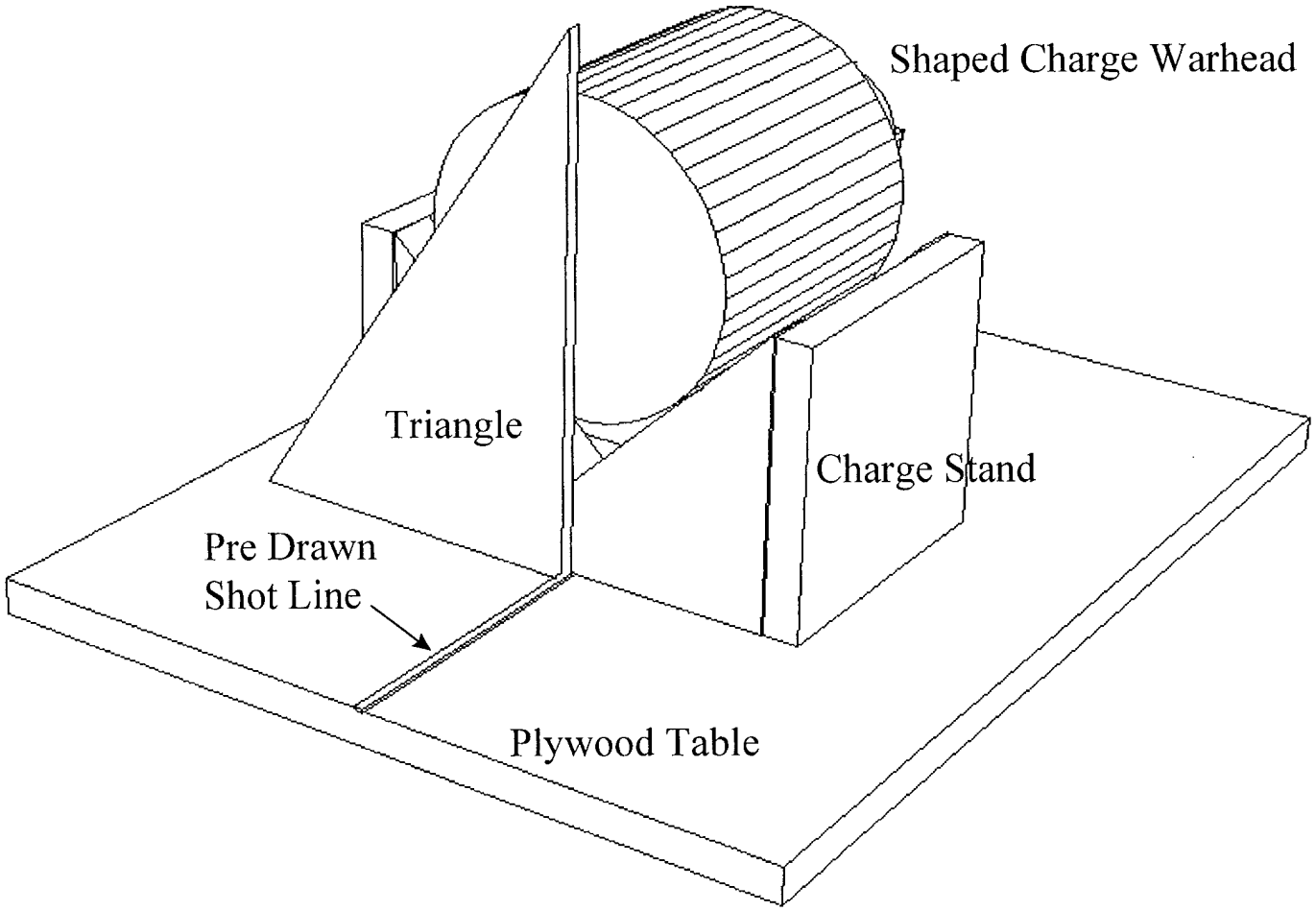


Figure 9b. <u>Front of warhead centering with plastic triangle</u>

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GLOSSARY

Definitions List

Armor System - Combination of materials in geometric configuration designed to provide protection against a threat.

Charge Stand - Usually a plywood stand used to support and control the height and direction of a CE warhead (shaped charge).

CE Warhead - An explosive munition containing chemical explosive and "liner" material, which forms high-velocity jet on initiation of explosive.

Test Site Table (Range Table) - Heavy steel table at test site designed to withstand many CE explosions.

Test Table (Shot Table) - Typically a piece of 1-in plywood, sometimes with 2-in × 4-in studs, used to improve level and flatness of existing range test site table.

Level Line - Horizontal reference line placed upon front surface of target to be tested.

Plum Line - Vertical reference line placed upon front surface of target to be tested.

Alignment or Reference Mark - Marks placed on target to aid range technician in setting target at appropriate elevation, azimuth, and obliquity.

Cross-hairs - Intersection of level line and plumb line on front surface of target.

Standoff - The distance between impact point on target front surface and reference point on CE warhead (usually front edge of liner).

Shot Line - Line of intersection, specified by engineer or test director, that a CE warhead jet will make as it traverses an armor system.

Azimuth - Angle, in horizontal plane, between impact shot line and armor longitudinal axis.

Elevation - Angle, in vertical plane, between armor longitudinal axis vector and impact shot line.

Obliquity - Angle, in deviation of a line or plane, between normal to front plate (or normal to some reference plate in armor package, and the shot line.

Target Alignment - Procedure used to properly position a target, to ensure that shot line through the target by the CE warhead jet is as specified by the test engineer.

CE Warhead Alignment - Procedure used to properly position the CE warhead so that the jet produced by this warhead traverses an armor package along a particular shot line as specified by the test engineer.

Impact Point - Location marked on target or referenced in drawings where armor plate, or first plate, is to be impacted by jet produced by CE warhead.

Test Site - Area or facility where armor system performance is to be tested with CE warhead.

Adjustment Wedges - Small wooden wedges used in leveling the CE warhead and stand.

Test Engineer (Project Engineer) - A skilled person who plans, devises, or manages the controlled effort of a test.

Test Director - Experienced personnel trained to carry out test plan procedures by the Test Engineer, efficiently and effectively, while maintaining safe working conditions and overall care of test facility.

Tool List

90° Triangle

Framing Square

Framing Level

Machinist's Level - 4 in

Gunner's Quadrant

Wedges

Pencil

Paint Marker

Inclinometer

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